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New nesting record of *Phoenicopterus chilensis* Molina, 1782 (Phoenicopteriformes, Phoenicopteridae) using a drone in Junin National Reserve, Peru

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Abstract. Chilean Flamingo, *Phoenicopterus chilensis* Molina, 1782, inhabits the Andes and is listed as Near Threatened by the International Union for the Conservation of Nature. Denver Zoo Conservation Alliance and Junin National Reserve conducted field and drone surveys for *P. chilensis* in Lake Junin, Peru. Nests were found along muddy shorelines, with one area showing a high concentration of nests, chicks, and adult individuals. These results indicate significant temporal changes in population structure and nesting conditions, highlighting the utility of drone surveys for monitoring high-Andean waterbird colonies and informing conservation strategies for *P. chilensis* in this critical breeding habitat.

Key words. Andes, chicks, Chilean Flamingo, Lake Junin, nests, remotely piloted aircraft system

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Introduction

Flamingos are a small, monotypic group of wading birds that belong to the order Phoenicopteriformes, family Phoenicopteridae. They have a highly specialized ecology (Torres et al. 2014; Bock 2021), and their preferred habitats are large, shallow marine marshes, estuaries, lagoons, and lakes, preferably brackish environments, and at elevations from sea level to 4,000 m (MINAGRI 2013). The order Phoenicopteriformes includes six species, of which four occur in South America, with three of these in the Andes (Bock 2021). These three flamingo species belong one of two genera: *Phoenicoparrus* Bonaparte, 1856, which includes *P. andinus* Philippi, 1854 (Andean Flamingo) and *P. jamesi* Sclater, 1886 (James's Flamingo), and *Phoenicopterus* Linnaeus, 1758, which includes *P. chilensis* Molina, 1782 (Chilean Flamingo).

Among the three flamingo species, *P. chilensis* is generally the most common across much of its range (More et al. 2020; Suarez-Pingo 2020), which has a wide geographical distribution from lowland wetlands to high-altitude lagoons (Tobar et al. 2017). *Phoenicopterus chilensis* is currently listed as Near Threatened in the International Union for the Conservation of Nature Red List due to intensive egg harvesting, hunting, tourism-related disturbance, habitat alteration from mining, and breeding-site disturbances caused by water irrigation projects (Birdlife International 2018). This species usually reproduces during the southern summer, and eggs are laid between January and March (Medrano and Chamorro 2010; Vizcarra 2014). In Peru, five nesting sites have been documented: (1) Laguna Salinas in Arequipa (Ugarte-Núñez and Mosaurieta-Echegaray 2000), (2) Lake Junin in Junin (Medrano and Chamorro 2010), (3) Ite Wetlands in Tacna (Vizcarra 2014), (4) Yaurihuiri Lake in Ayacucho (Ortiz et al. 2025), and (5) La Niña Lake in Piura (More et al. 2020).

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Lake Junin is a shallow permanent freshwater Puna high-altitude lake, between 4,080 and 4,125 m above sea level (SERNANP 2019). It is the second largest lake in Peru and is part of Junin National Reserve, a protected natural area created in 1974 by the Peruvian government (SERNANP 2019). The most important group of animal species within this reserve is birds, with 150 species recorded, including resident, migratory, and occasional visitors (SERNANP 2019). *Phoenicopterus chilensis* is the only flamingo species found in the lake that, aside from its role in the ecosystem, has been integrated into local customs and traditions. There are multiple stories from the elders of the Junin villages that speak of the great abundance of flamingos decades ago, how their meat and eggs were consumed, and how their feathers were used for ornamental purposes (Medrano and Chamorro 2010).

There is little historical information on the flamingo reproductive events in the northern Paucarcoto sector of the lake in Junin National Reserve (Ortiz et al. 2025). It was not until 2005 that a group of park rangers from the reserve recorded a breeding colony in the western sector of the lake (Ortiz et al. 2025). Since 2010, the number of flamingos (adults, juveniles, chicks, and nests) has been recorded intermittently (Medrano and Chamorro 2010), and reproductive events were recorded in different areas until 2015 (Ortiz et al. 2025). However, nesting of *P. chilensis* has not been recorded in Junin National Reserve since around 2010, likely due to increased water levels that inundated nesting areas, followed by periods of water drawdown in Lake Junin (Ortiz et al. 2025; J. Hurtado pers. comm. 2024).

Since 2020, the Junin National Reserve and Denver Zoo Conservation Alliance, in collaboration with the Peruvian non-governmental organization Asociación Ecosistemas Andinos, have been carrying out bimonthly and quarterly censuses of the *P. chilensis* population at Lake Junin. These surveys use fixed-point counts from the lake's edge and water surface, conducted by Junin National Reserve - Servicio Nacional de Áreas Naturales Protegidas por el Estado (RNJ - SERNANP) (Medrano and Chamorro 2010). Field teams were divided into land- and water-based groups. Land teams consisted of two members, an observer and a recorder, who traveled to bird-count sites by land vehicle. Water teams included two observers, one with binoculars and one serving as a recorder, and a third person operating the boat.

However, fixed-point counts are limited by line-of-sight constraints. According to Holm et al. (2024), drone-based methods offer new possibilities for highly accurate and effective counting and mapping of waterbirds, especially in the breeding season. Following these observations, and given the need to survey larger areas, a proposal was made in 2024 to conduct new exploratory efforts. Two consecutive censuses using remotely piloted aircraft system (RPAS; i.e. drone) equipment were conducted, adapting the methodology established by Vas et al. (2015) and Luque-Fernández et al. (2021) to achieve a more precise estimate of flamingo abundance, as well as to locate additional nesting sites.

Methods

During the dry season in September and October 2024, two censuses of *Phoenicopterus chilensis* were conducted at Lake Junin by three park rangers from Junin National Reserve. They were accompanied by a member of the Denver Zoo Conservation Alliance who used an RPAS (Autel EVO 2 Pro) to survey areas with known or potentially occupied *P. chilensis* colonies that were difficult to access by land. The areas were determined by past records, local people, and park rangers, and were chosen because they were difficult to assess using binoculars or a telescope from ground-based surveys. Flights were conducted between 9:00 to 12:00 h, with flight duration constrained by the high elevation and low air density of the study area, which resulted in shorter flight times compared to sea-level conditions. The takeoff location was 200 to 300 m from the study area. The flight distance ranged from 2 to 5 km, depending on the study area and selected flight plan.

Drone flights lasted 20–30 min, and they performed two types of surveys. The first was site exploration to identify potential locations of unknown flamingos, flown at 100 m above the ground, and the second was grid routes for *P. chilensis* colonies, flown at 60 m above the ground. The grid routes covered a rectangular area with a side length of approximately 500 m, resulting in a total surveyed area of about 59,926 m^2 (ca. 6 ha). Although the takeoff locations were at a higher elevation than the survey areas, flight altitude was standardized relative to the lake surface; therefore, elevation differences did not influence detection or counts. The RPAS flew at 30 km/h for the site exploration flights and 18 km/h for the grid routes in Conoc-Ondores (Figure 1), with the camera angled at 45° and 90°, respectively. The exploration flights involved taking photographs and videos of the *P. chilensis* colonies. Photogrammetry, the process of stitching individual images together to create a geospatial orthomosaic map, requires images taken along consecutive, overlapping legs so the software can find similar features between images. Therefore, grid routes were flown with 80% front overlap and 60% side overlap.

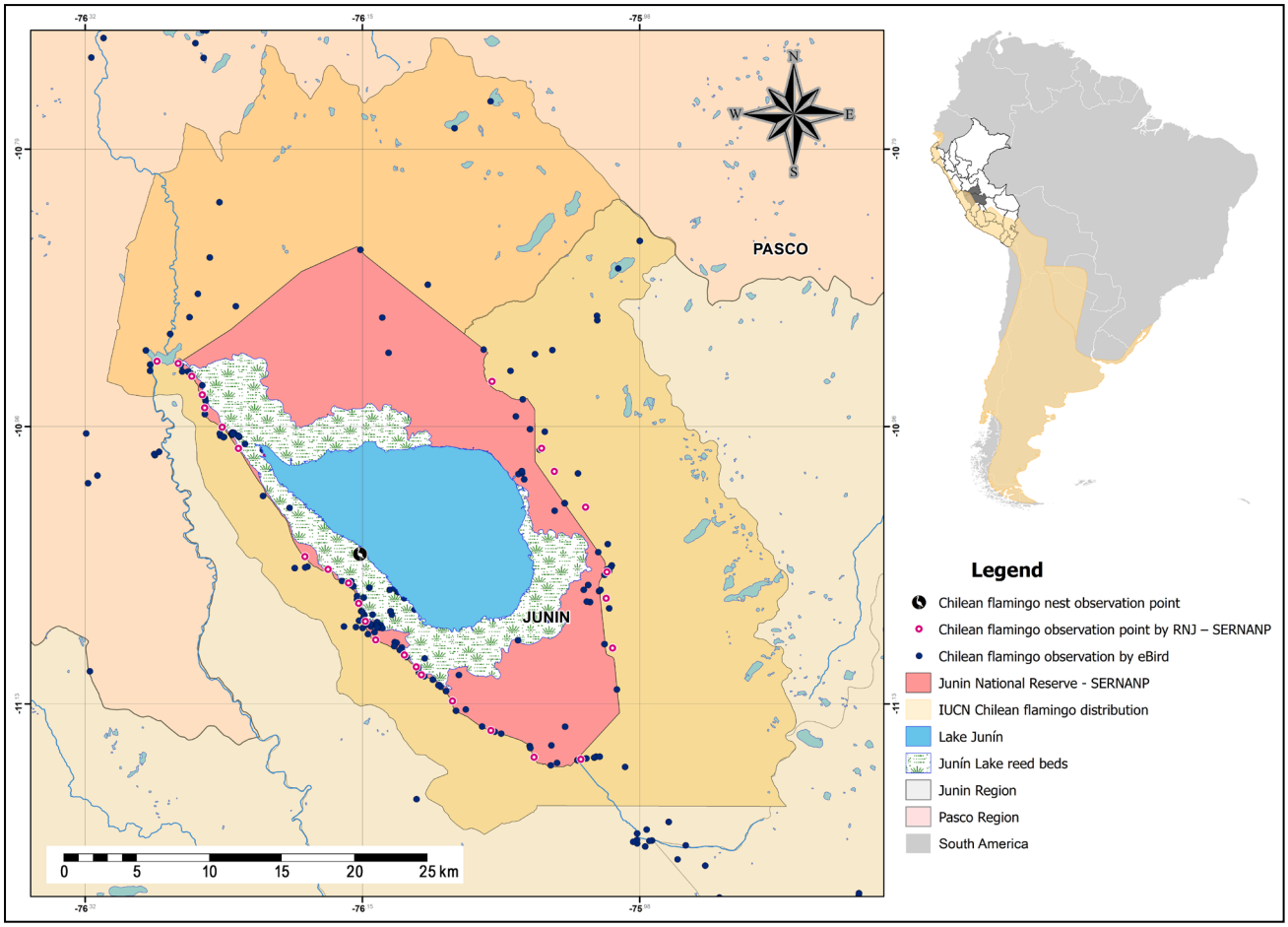

Figure 1. *Phoenicopterus chilensis* sightings in Junin and Pasco regions, with the flamingo nest record in black squares. Pink circles represent observation points reported by Junin National Reserve - SERNANP (2024). Blue circles represent records from eBird (2025) and tan area represents the distribution of *P. chilensis* as reported by the IUCN (BirdLife International 2018).

The images from the grid flight plans were processed with Agisoft Metashape Pro v. 1.7.2 (trial version) to create the orthophoto. With this orthophoto, a manual counting process of the groups of adult flamingos and chicks was carried out with the help of collaborators. The distribution map was generated using ArcGIS Desktop (ESRI 2020).

Results

***Phoenicopterus chilensis* Molina, 1782**

Figures 2, 3

Observations. PERU — Junin • Department of Junin, Province of Junin, District of Ondores; −11.0560, −76.1585; 4106 m a.s.l.; 11.IX.2024 and 7.X.2024; Henry Tinoco-Vega obs.

The flamingo nests were located among cattails and in shallow water near the lake's edge, in the middle of the muddy shoreline.

This flight plan determined that the Conoc sector had the highest concentration of individuals. A total of 1546 *P. chilensis* adults and 118 chicks were counted in September, in addition to 165 active nests, 42 empty nests, and 125 eggs out of the nests (Figure 2). In October, a second flight was carried out at Conoc (Figure 3), which was flown with the same flight parameters as the surveys in September. A total of 275 *P. chilensis* adults, 28 chicks, 187 active nests, and 133 empty nests were counted, and notably, 305 eggs were found outside of nests (Table 1; Figure 3).

Identification. The species was morphologically identified using photographic documentation and verified by the co-authors (JCHV, HTV, MAL, LCR, EE, MJH, JA, WS, REP) using size and colouration as distinguishing characteristics; these birds have large bodies with long necks and small heads. Their plumage is pale pink, and their legs are yellowish-grey, with contrasting red knees and feet. The bill is

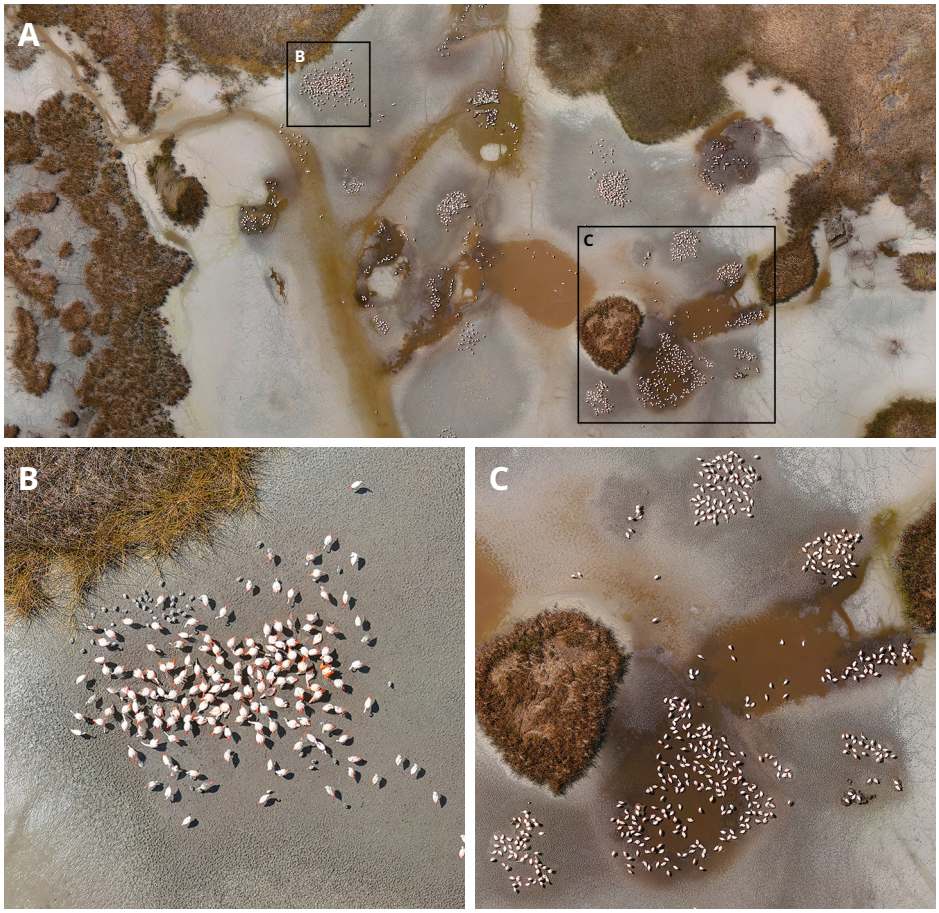

Figure 2. A. Orthomosaic of the Conoc sector (by the grid method), where the highest concentration of *Phoenicopterus chilensis* was present, September 2024. **B, C.** Areas in **A** enlarged: (**B**) group of feeding flamingos and nests with laying flamingos; (**C**) adults and chicks.

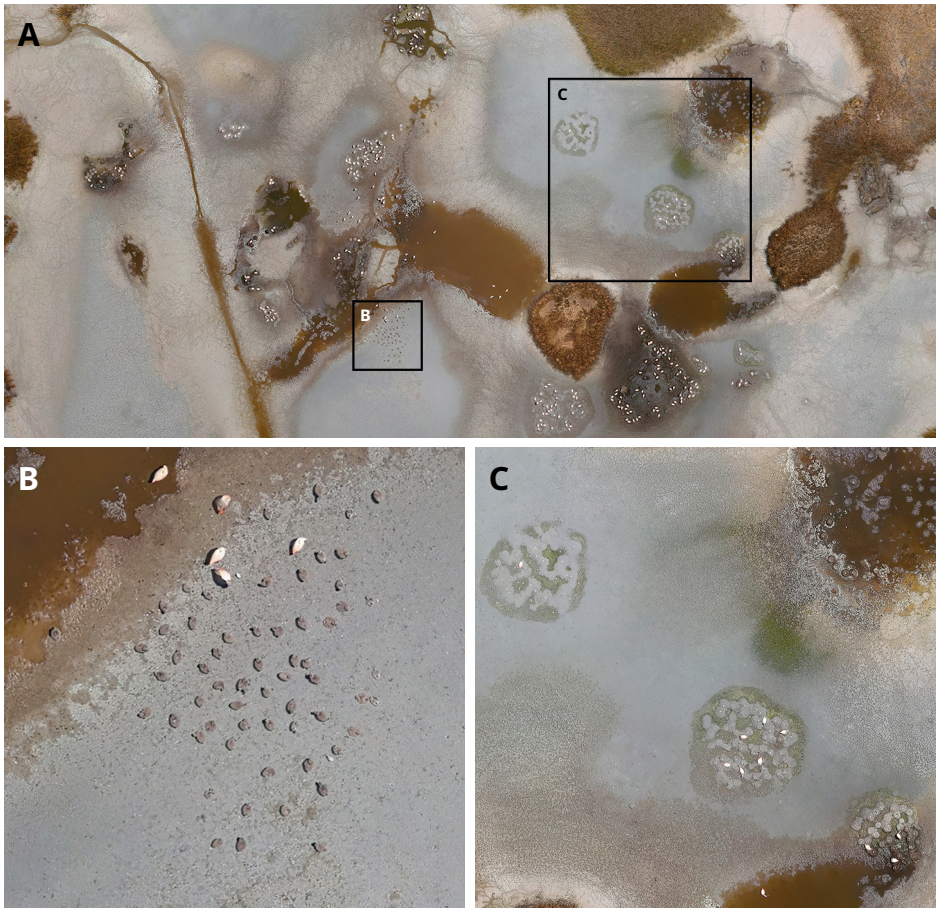

Figure 3. A. Orthomosaic of the Conoc sector (by the grid method), where the abundance of *Phoenicopterus chilensis* was recorded, October 2024. **B, C.** Areas in **A** enlarged: (**B**) group of flamingo chicks and protective adults; (**C**) group of adult flamingos in laying positions and empty nests.

Table 1. Total number of individuals and nests of *Phoenicopterus chilensis* in Conoc sector.

Month	Number of individuals		Number of nests		
	Adults	Chicks	Nest with eggs	Nests without eggs	Eggs out of nests
September	1546	118	165	42	125
October	275	28	187	133	305

mostly pale with a distinctive black tip. Immature individuals are grey with brown and pink markings. The development of young birds can be divided into three age groups: chicks (<15 days old), which are covered in white down and have a salmon-pink bill with coral-red legs; pre-juveniles (1–3 months old), which have grey down due to a double down coat that turns to brownish down as the white down is shed, with the bill darkening and the legs turning dark grey; and juveniles (4–5 months old), which have streaked plumage, including pale brown dorsal feathers with a dark rachis, white underparts, and pale salmon inner coverts. Their bill is decurved, with a bluish base and charcoal-grey tip, and their legs are pale grey. The nest is usually a truncated cone of mud with a shallow bowl at the top, and individuals of the species only have one egg per breeding season (Del Hoyo et al. 2024).

Discussion

The use of images captured by an RPAS to count *Phoenicopterus chilensis* individuals across different age groups and identify nesting sites is a method that has not previously been used in Junin National Reserve; however, it was used in Salinas and Aguada Blanca National Reserve in 2019 during reproductive events (Luque-Fernández et al. 2021), as well as in Italy for *Phoenicopterus roseus* Pallas, 1811 during the 2018–2019 breeding seasons (Valle 2022).

This methodology, unlike direct observation used in Junin National Reserve in previous years, enabled access to otherwise unobservable flamingo colonies, such as those surrounded by reeds, which are mostly very dense and almost impenetrable (Medrano and Chamorro 2010). Images taken with the RPAS could identify flamingo adults, chicks, and nests, something that could not be done with direct observation. This is particularly valuable given that *P. chilensis* in Junin National Reserve is currently using nesting sites other than those recorded in 2014. These new sites are in areas surrounded by tall aquatic vegetation, which obstructs visibility from the shore or boats, making direct observation difficult. Flamingos often reuse the same nesting sites within a colony, but they may shift locations in response to changes in water levels (Bucher and Curto 2012), such as those observed in Lake Junin due to damming and water discharge (J. Hurtado pers. comm. 2024). Other factors that may drive flamingos to move nesting sites include climate change, human disturbance (Midwest Center for Biodiversity 2023), and food shortages (Meziani 2011). Nevertheless, since 2014, no nests or chicks have been observed through direct observation, and the sites surrounded by tall vegetation may partly explain why nesting activity has gone unrecorded since 2014.

The use of images to count individuals has proven to be an effective system for conducting flamingo censuses, as it takes less time and requires fewer personnel and transport vehicles. With the use of RPAS, only two people are required: the drone pilot and an assistant. Despite these advantages, limitations include weather conditions, drone type, sensor resolution, and the potential costs and time constraints associated with image processing, which may require specialized training and substantial office-based analysis time.

As Holm et al. (2024) concluded, the use of RPAS provides new opportunities for accurate and effective counting and mapping of waterbirds, particularly during the breeding season and especially for colonial ground-nesting species. Our study confirms this potential, as drone imagery successfully captured *P. chilensis* at both nesting and resting sites in natural habitats such as those found in Junin National Reserve, Peru. These images proved valuable for conducting population censuses of this species in the future.

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Additional information

Conflict of interest
The authors declare that no competing interests exist.

Ethical statement
No ethical statement is reported.

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Author contributions
Conceptualization: JCHV, HTV, MAL, LCR, MTH, JA, WS, REP. Funding acquisition: JCHV, HTV, LCR, MTH, REP. Investigation: CHV, HTV, MAL. Methodology: HTV, LCR, WS. Resources: JCHV, HTV, LCR. Project administration: JCHV, HTV, MAL, LCR, MTH, JA, REP. Writing – original draft: REP. Writing – review and editing: JCHV, HTV, MAL, LCR, MTH, JA, WS, REP.

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Data availability
All data that support the findings of this study are available in the main text.

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